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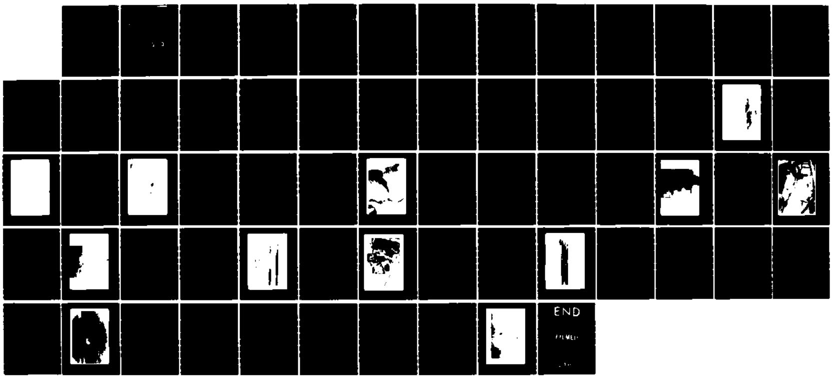

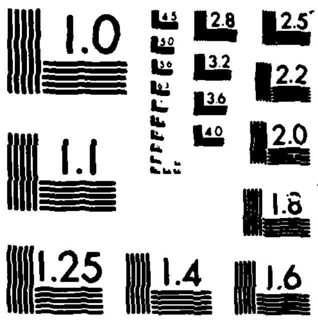

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CENTERVILLE BEACH
PROJECT COMPLETION REPORT

FPO-1-77(3)
JULY 1977

OCEAN ENGINEERING AND CONSTRUCTION PROJECT OFFICE
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
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This report describes the development of a unique liquid transfer facility, designed & constructed as a solution for a sewer outfall at Centerville Beach, CA. The beach in this area has an active surf zone and a rugged shore (Con't)

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terrain that prevented the cost-effective installation of ordinary pipeline materials. To overcome these environmental conditions, ocean engineers selected a 4-inch ID, high-density polyethylene pipe protected by helically-wrapped, steel-armored wires, and having jute and tar coverings.

ABSTRACT

This report describes the development of a unique liquid transfer facility, designed and constructed as a solution for a sewer outfall at Centerville Beach, California. The beach in this area has an active surf zone and a rugged shore terrain that prevented the cost-effective installation of ordinary pipeline materials. To overcome these environmental conditions, ocean engineers selected a 4-inch ID, high-density polyethylene pipe protected by helically-wrapped, steel-armored wires, and having jute and tar coverings.

The use of plastic pipe for liquid transfer is not new, but use of such pipe in the oceans has been limited by its lack of abrasion-resistance and durability. The helically-wound, steel-armored wires provided abrasion resistance, weight, strength, and resistance to pipe collapse.

The major conclusion resulting from this project is that the pipeline material and its installation method introduced a new underwater construction capability, one which can be applied to similar projects.

ACKNOWLEDGEMENTS

In August 1975 members of various naval commands were deployed to the U. S. Naval Facility, Centerville Beach, Ferndale, California, in accordance with COM31STNCR Operation Order 1-75 to install a sewer outfall and necessary appurtenances 3,000 feet offshore.

Assisting in this operation from the Ocean Engineering and Construction Project Office (FPO-1), CHESNAVFACENGCOM, were Mr. David A. Raecke, who served as Project Manager and design engineer for customer activity and as the person authorized to approve/disapprove the technical matters relating to the complete facility and to make final acceptance of the work performed. Mr. Raecke was accompanied by Mr. Alexander Sutherland and Mr. Daniel F. Pullen who provided construction engineering field support. The use of flexible, armored, plastic pipe was recommended by Mr. William G. Sherwood.

The installation of the sewer outfall line was performed by members of UCT-2 under the command of LCDR J. A. Stamm.

A craftmaster and crew were provided by ACB-1 to provide LCU support for the duration of the offshore installation.

Administrative, berthing, messing, and logistics support were provided by the Naval Facility at Centerville Beach.

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EXECUTIVE SUMMARY

BACKGROUND. Many naval bases in the United States, its territories, and in foreign countries are located near oceans or rivers that access to oceans. To keep these areas free from pollution, the Chief of Naval Operations has directed naval bases to meet federal and state environmental standards.

In the summer of 1975, the standards required the Navy to install a sewer outfall line at the Naval Facility, Centerville Beach, California. The outfall line began at the top of a hill, 260 feet above the beach, and crossed approximately 1,000 feet of rough terrain until it reached the beach, which was flat and smooth. Here, it extended 3,000 feet offshore, to a water depth of 50 feet. The offshore line passed through a dynamic surf that stretched 500 to 1,500 feet seawards depending on the height of incoming waves. The seafloor consisted of medium-to-coarse, fairly dense sand, with no rocks.

The sewer outfall project began when the EPA and the California Regional Water Quality Control Board requested the Naval Facility at Centerville Beach, near Ferndale, to discontinue discharging effluent into an adjacent stream. One way to meet this request was to connect the Naval Facility's treatment plant to Ferndale's plant with an onshore sewer line. However, the Ferndale City Council would not construct or operate such a line. If the Navy constructed the line, right-of-way acquisitions would be required which were costly and time-consuming. It was decided, therefore, that the most economic way to meet the state and federal pollution requirements would be to construct an outfall line that discharged into the Pacific Ocean from the Naval Facility.

Accordingly, WESTNAVFACENGCOM requested NAVFACENGCOM to design an offshore and onshore sewer line that could withstand a maximum discharge of 25,000 gallons of effluent per day, and requested that the NCF install the line.

PIPE DESIGN. The pipe design and its installation were turned over to CHESNAVFACENGCOM (FPO-1) by NAVFACENGCOM. Surveys indicated that the site's terrain and surf conditions precluded a line that used standard steel or concrete pipe sections. Instead, it was necessary to design a pipe that was rugged enough for the environment, and had a unit weight which would eliminate a need for stabilization. In addition, the pipeline had to be installed in less than 48 hours because of weather constraints.

The solution to these design and construction requirements was a high-density, polyethylene pipe protected by helically-wrapped, steel-armored wires, and having jute and tar coverings. The polyethylene pipe had an inside diameter of 4 inches (nominal) and an outside diameter of approximately 5 inches. The overall diameter of the composite section was 6.05 inches. The pipe weighed 17.6 pounds per foot empty in air, 4.8 pounds per foot empty in seawater, and 10.5 pounds per foot full in seawater. It had a tensile strength greater than 150,000 pounds. It was flexible and could be bent to a radius of about 5½ feet. The pipe was virtually inert to seawater and sewage. Also, it was not subject to attack by marine life because its smooth surface afforded little opportunity for organisms to attach themselves. The steel-armored wires were zinc-coated (galvanized) carbon steel. Fifty-two wires with a diameter of 0.300 inches were used to armor the pipe, each wire individually tar-coated for additional corrosion protection. Because of its flexibility, the pipeline was coiled on four reels, each holding 1,000 feet of pipe with connections on each end. The pipe was produced by Simplex Wire and Cable Company, Portsmouth, New Hampshire.

INSTALLATION. To install the shore section of the pipeline, one reel of cable was placed at the crest of the hill. A bulldozer pulled the pipeline downhill while a braking force was applied against the cable reel. On the beach, the pipeline was connected to a thrust block and beach anchor.

The remaining cable reels were loaded on an LCU, which served as a moored work platform. As the pipeline was unreeled from the LCU, it was connected to a hauling line with floats attached. A bulldozer on the beach then pulled the line ashore.

When the 3,000 feet of pipeline had reached the shore, the shore and sea lines were connected, the floats were removed, and the pipe sank and stabilized on the seafloor by wave action. The diffuser was overboarded from the LCU and positioned on the bottom. Divers then connected the offshore pipeline to the diffuser.

When the pipeline was connected to the sewage treatment plant, a fluorescein sea marker dye was pumped into the line. Its dispersion through the diffuser confirmed the system's performance.

The installation lasted 20 days, with 12 days lost to bad weather.

SUMMARY. There were no injuries or serious mishaps during the execution of this project. This good fortune, combined with careful project planning and excellent teamwork, resulted in the project's being completed on time and within budget. The sewer outfall was operationally successful and satisfied EPA and State of California requirements. A survey report made after the installation showed that the facility was stable and performing well.

CHAPTER 1

PROJECT BACKGROUND

1.1 WATER QUALITY CONTROL REQUIREMENTS. The Centerville Beach sewer outfall project was undertaken to meet EPA and State of California water quality control requirements. The Naval Facility at Centerville Beach had been discharging its treated effluent into an adjacent, unnamed stream, which was a tributary of the Pacific Ocean. Since stream pollution is prohibited under the California North Coastal Basin Plan, continuance of the discharge was unacceptable to the State.

1.2 PLANNING CONSIDERATIONS. WESTNAVFACENGCOM proposed to solve the problem by constructing a pipeline from the Naval Facility to the City of Ferndale's sewage treatment plant as part of FY 1972 MCON Emergency Construction Project P-031. This proposal was hindered by cost problems for Ferndale and the Navy. Although Ferndale would accept the sewage for treatment and discharge, the city would not construct, own, or operate the pipeline. Navy construction of the line was considered unfeasible because of the time and cost required for extensive right-of-way acquisitions. In addition, the Navy would be responsible for the line's life-cycle maintenance.

WESTNAVFACENGCOM then investigated two alternatives: (1) the zero-discharge method, and (2) a Pacific Ocean discharge. The zero-discharge was uneconomical because of the need to purchase 20 acres of land and to construct and maintain new evaporation ponds. The ocean discharge was the only solution which meet EPA and State of California regulations.

1.3 TASKING. The following references pertain to project tasking:

(a) NAVFACENGCOM ltr PC-2A/RHM of 30 April 1974

(b) WESTNAVFACENGCOM spdltr 09A2.X:NSL:rn Ser 092A/202 of 22 April 1974

(c) CHESNAVFACENGCOM msg 161403Z July 1974

(d) CINCPACFLT ltr FF1-1 11000 Ser 44/C490 of 18 July 1974 (C)

(e) CNO msg 131836Z August 1974

(f) CHESNAVFACENGCOM ltr FPO-1E8:db 11345 of 11 March 1975

(g) COMNAVSURFPAC msg 100213Z April 1975

Reference (a) directed CHESNAVFACENGCOM to provide engineering support, planning, and coordination for the installation of the offshore portion of a Pacific Ocean sewer outfall, as requested by reference (b).

In reference (b), WESTNAVFACENGCOM retained responsibility for the design of the onshore portion of the line. Subsequent to reference (a) CHESNAVFACENGCOM submitted a preliminary design and installation for the offshore line. During discussions of the plan between WESTNAVFACENGCOM and CHESNAVFACENGCOM personnel, it was determined that CHESNAVFACENGCOM should design both the offshore and onshore lines to insure that the system design and installation procedures were compatible. Thus, CHESNAVFACENGCOM informally accepted the tasking assignment for the design and installation of the entire sewer outfall. WESTNAVFACENGCOM retained the responsibility for the design and installation of additional treatment facilities to meet EPA and State of California standards for tertiary treated sewage effluent.

By reference (c), CHESNAVFACENGCOM requested that UCT-2 be tasked to install the sewer outfall and to provide personnel and equipment support. The project was included as part of UCT-2's proposed workload, reference (d), and was subsequently approved by CNO, reference (e).

By reference (f), CHESNAVFACENGCOM requested that ACB-1 provide small craft and personnel support for the installation of the offshore portion of the sewer outfall. This tasking was accepted and passed to ACB-1 for action by reference (g).

CHAPTER 2

PROJECT PLANNING

2.1 DESIGN REQUIREMENTS. The design requirements established by WESTNAVFACENGCOM for the sewer outfall line were:

a. A maximum discharge of 25,000 gallons per day, with the discharge to be intermittent from a 1,000-gallon holding tank.

b. A design life of 20 years.

c. An outfall line to be buried across the beach to mean lower low water.

d. A pipe to be installed above ground on the slope between the Naval Facility's treatment plant and the beach. (A short portion of the pipe immediately outside the boundary fence was to be buried to permit passage of livestock on adjacent farmland.)

e. A minimum disturbance of vegetation on the slope to limit future erosion.

f. Tertiary-treated effluent, with no solid wastes.

The maximum daily discharge rate was the rated capacity of the Naval Facility's sewage treatment plant. The plant operated on an average of 60 percent of capacity. The Naval Facility's proposed expansion was not expected to require a greater treatment or discharge capacity. Although WESTNAVFACENGCOM originally planned to install a 3-inch diameter pipe, a 4-inch diameter pipe was chosen to allow for a reserve capacity should the Naval Facility's expansion create a greater-than-anticipated load, and to handle the peak flows caused by the intermittent discharge from the holding tank. (The peak-flow consideration may have been an unanticipated design criteria. During the installation of the outfall line, the Naval Facility's Public Works' personnel reported that peak flows through the treatment plant occasionally exceeded a rate of 60,000 gallons per day, particularly during rainy weather. Infiltration of ground water into the sanitary sewer lines is suspected, and an unknown cross-connection to the storm drains may exist.)

The requirement to place the pipe above ground and to minimize vegetation disturbance on the slope was established because the area between the beach and the Naval Facility has a history of slope failure ranging from minor

slumping to major landslides. Any trenching or excavation for pipe or appurtenance burial, or any removal of vegetation might serve as a focus for future erosion or slope failure. Also, the rough terrain of the existing slope precluded the use of mechanized trenching equipment and manual labor.

2.2 SCHEDULE REQUIREMENTS. The EPA installation permit called for a cessation of the existing discharge by early calendar year 1976. In order to meet this deadline, the pipe had to be installed during the 1975 summer weather window. The months of June, July, and August have the most acceptable weather conditions for nearshore boat operations. May and September are marginally acceptable. From October through April, the prevalence of high surf and inclement weather are too great to permit the installation of an offshore line. The installation of the outfall line was scheduled for late July of 1975. Figure 2-1 shows the project milestones and events.

2.3 ORGANIZATIONAL RESPONSIBILITIES. The following is a list of the major contributors to the project's accomplishment. The Major Functions column is not a listing of all the functions performed by a particular command or unit, but rather its most identifiable contribution.

ORGANIZATION	MAJOR FUNCTIONS
UCT-2	Provided the OIC (Beach Master) and personnel who performed the project's construction tasks. Provided diving gear, construction equipment, and small craft. Furnished input to operation plans.
ACB-1	Provided boat support, hardware for boat mooring, personnel services, and input to the operation plan for installation of the moor.
CHESNAVFACENGCOM (FPO-1)	Was responsible for installing the offshore line. This responsibility included engineering and on-site technical support, surveys, meteorological studies, project operation plan preparation, procurement of pipeline material,

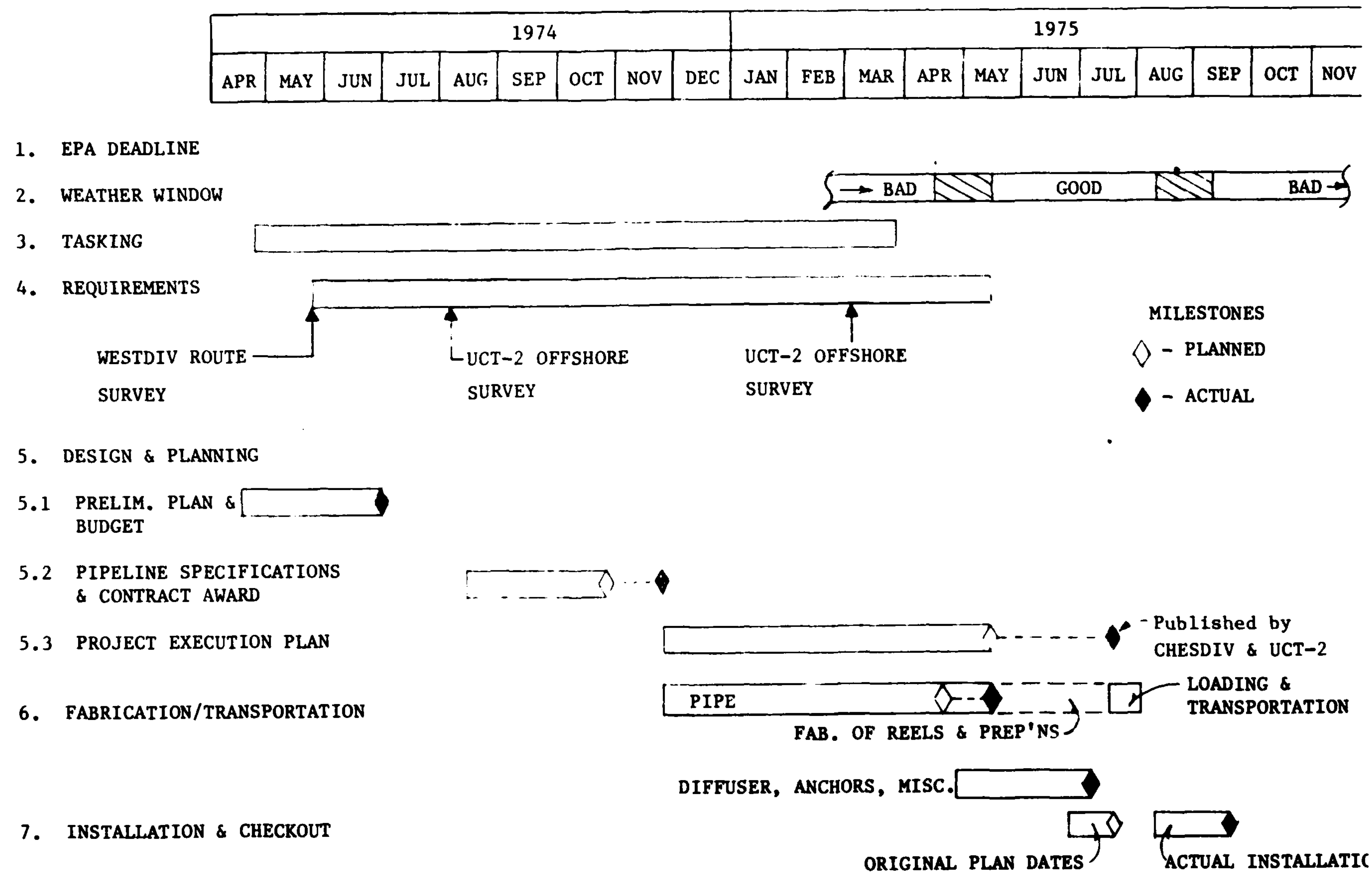


FIGURE 2.1 PROJECT MILESTONE AND EVENT SCHEDULE

ORGANIZATION	MAJOR FUNCTIONS
	financial management, final acceptance, inspection, and project completion report. Generated tasking requirements through the Chain of Command for UCT-2 and ACB-1. Coordinated operations between UCT-2, ACB-1, and WESTNAVFACENGCOM.
WESTNAVFACENGCOM	Had overall responsibility for the MCON project. Prepared the environmental impact statement, and secured required permits. Procured pipeline easement for the land line.
Naval Facility	Final user. Provided local purchase, logistics support, messing, and berthing for UCT-2 and CHESNAVFACENGCOM personnel. Supported construction work.

CHAPTER 3

ENGINEERING DESIGN AND EXECUTION PLANNING

3.1 FACILITY AND INSTALLATION SYSTEM ANALYSIS. A system analysis was conducted to consider the various functional and installation requirements of the outfall line and the constraints imposed upon the system by the environment. Several alternative configurations of the outfall line were proposed and were compared to the project requirements and constraints before selection of the final configuration. Consideration of the functional and installation requirements and environmental constraints showed that the pipeline for the Centerville Beach project had to be:

- Installed above ground without the use of mechanical equipment - To minimize slope and vegetation disturbance, which might induce erosion and slope failure.

- Flexible - To accommodate uneven ground and soil slumping on land, the stress of surf action during installation, and scour of the seafloor after installation.

- Corrosion and abrasion resistant - To protect the line during its exposure in the ocean environment.

- Joined with a minimum of connections - To expedite installation and reduce maintenance.

- Installed rapidly - Because adverse weather and sea conditions could develop within a 24-hour period.

- Negatively buoyant - To promote rapid burial of the pipeline by wave action.

In addition, because the narrow beach at the installation site prevented the assembling of long lengths of pipe perpendicular to the shore for pullout to sea, the pipeline had to be either coiled on reels or faked-down in loops.

An installation method that permitted pulling the offshore line to the beach from a work platform moored outside the surf zone had advantages over the reverse procedure, i.e., pulling the pipeline from the beach into the water. These advantages included minimizing exposure of the pipe to surf conditions and eliminating the need to transport large quantities of material over a soft sand beach. These considerations also affected the selection of pipeline material.

3.1.1 Alternative Pipeline Material Concepts. Many design concepts were studied in order to meet the above requirements. The advantages, disadvantages, and reason(s) for rejection of nonselected concepts are summarized below.

3.1.1.1 Steel

- Advantages - Strong, flexible in long lengths, abrasion-resistant, negatively buoyant.

- Disadvantages - Available only in short (20-30 feet) lengths, required 100-150 connections (by welding, screw joints, flanged connections); subject to damage by surf action during installation; design life for unprotected pipe less than 10 years because of corrosion; cathodic protection impractical; coated steel pipe subject to accelerated corrosion at breaks in coating; not practical for pulling from boat to beach.

- Rejected - Because of design life and large number of connections during installation.

3.1.1.2 Concrete

- Advantages - Abrasion and corrosion-resistant, negatively buoyant.

- Disadvantages - Available only in short lengths (10 feet); must be placed on excavated grade; subject to damage by scour (joint separation); could not feasibly be fabricated and emplaced in a single day; ocean installation required equipment unavailable to NCF.

- Rejected - Disadvantages too numerous.

3.1.1.3 Unarmored Plastic Pipe (e.g., polyethylene or polyvinylchloride.

- Advantages - Corrosion-resistant; flexible; could be prefabricated in long lengths on beach and pulled into water.

- Disadvantages - Low strength for pulling through surf zone; slightly buoyant to very slightly negatively buoyant in water; required extensive installation of anchoring material (steel or concrete) for stabilization.

- Rejected - Primarily because of need to attach anchors for stabilization; installation would require longer than 1 day.

3.1.1.4 Fiber-Reinforced Plastic Pipe

- Advantages - Same as for unarmored plastic pipe, plus good tensile strength.

- Disadvantages - Same as for unarmored plastic pipe, with the exception of strength.

- Rejected - Same as for unarmored plastic pipe.

3.1.1.5 Industrial Hoses (e.g., oil-loading hose, rotary-drilling hose).

- Advantages - Same as for unarmored plastic pipe.

- Disadvantages - Same as for unarmored plastic pipe; unknown tensile strength (material was designed to resist high internal pressure, not tensile stress).

- Rejected - For same reasons for as unarmored plastic pipe.

3.1.2 Selected Pipeline Design. The pipeline selected for the onshore and offshore portions of the sewer outfall was a unique material made of a high-density polyethylene pipe protected by helically-wrapped, steel-armored wires, and having jute and tar coverings (Figure 3-1). This composite construction produced a rugged and durable pipe that met all design and installation requirements. The pipe was specifically designed for use in an ocean environment, and had a design life of 20 years. In addition, the pipe had a minimum-bend radius of 5-½ feet and a tension capacity, because of the steel armor wires, of approximately 150,000 pounds. These features permitted the pipe to be tested as if it were a cable. The steel-armored wires provided abrasion protection to the polyethylene pipe and also provided the weight for stabilization of the pipeline. The pipe could be fabricated in long lengths that minimized the number of connections.

3.2 FACILITY DESIGN. The layout of the sewer outfall is shown in Figure 3-2. The complete facility consisted of four major components:

a. A section of pipe approximately 850 feet long covering the land route from the beach anchor to the hilltop anchor.

b. A 3,000-foot length of pipe from the beach anchor seaward.

c. An outlet structure or diffuser at the seaward end of the pipeline.

d. Anchor blocks at the beach and at the top of the hill near the sewage treatment plant.

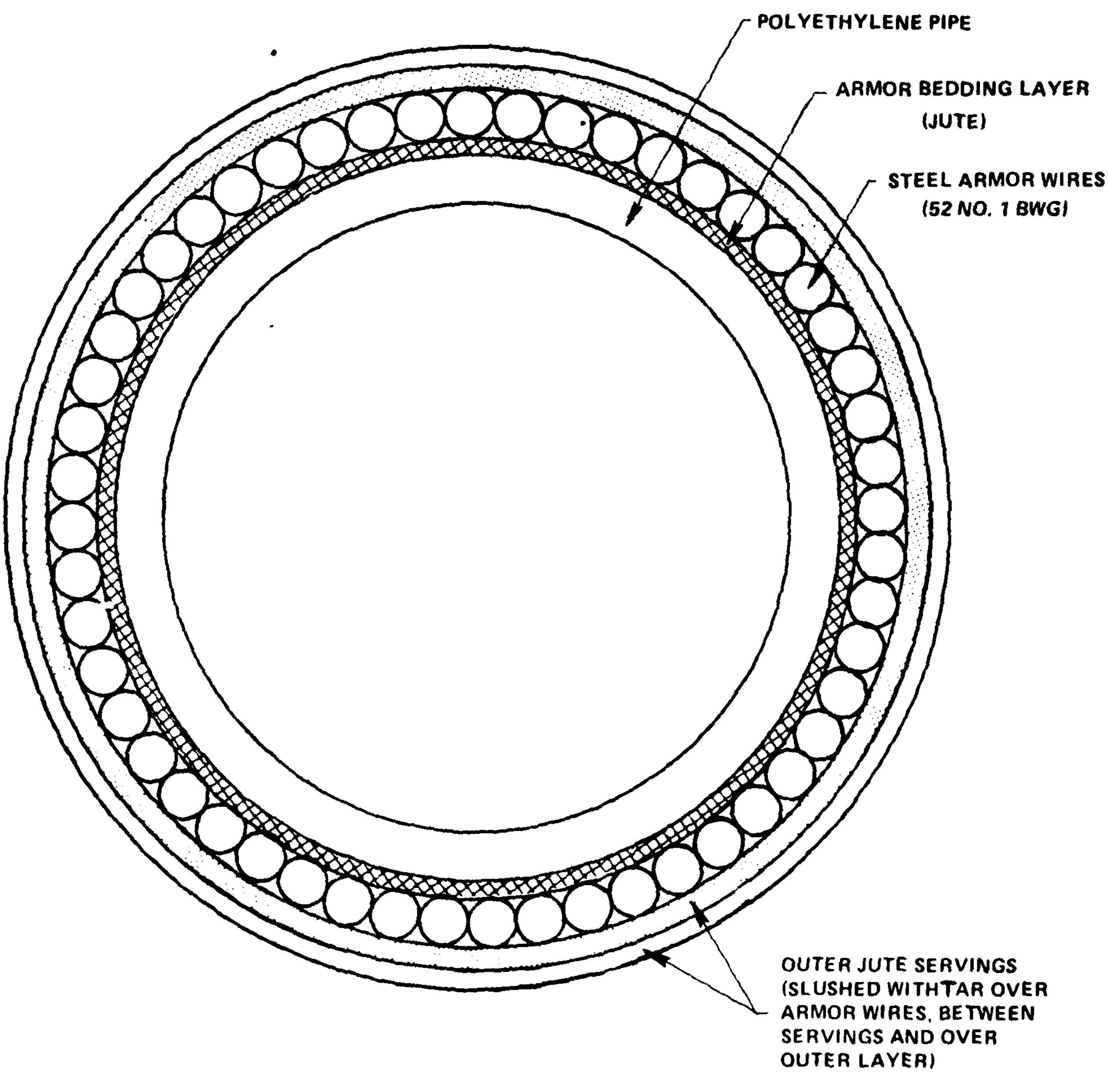


FIGURE 3-1

Cross-Section of
Steel-Armored Polyethylene Pipe

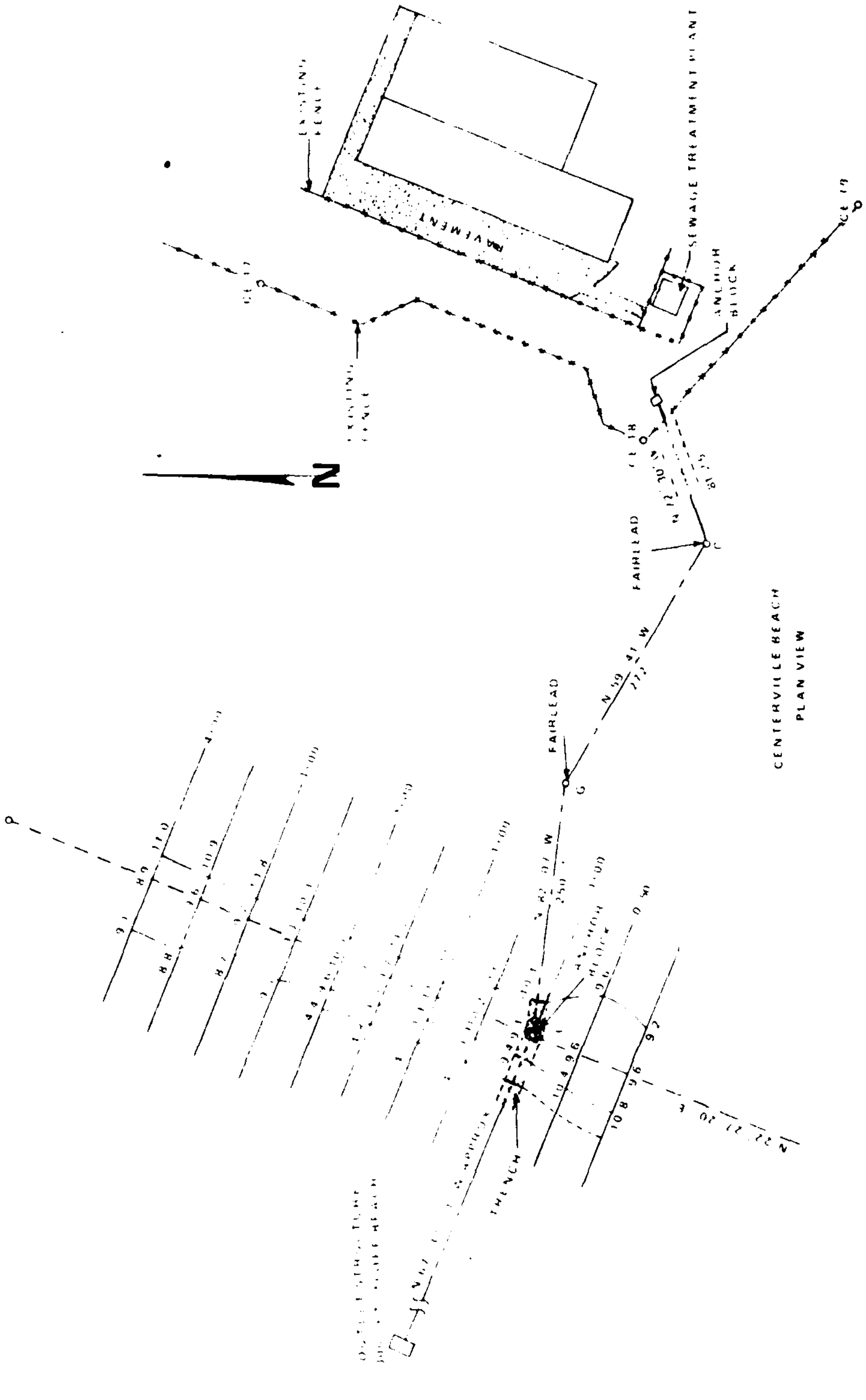


FIGURE 3-2

Overall Layout of Sewer Outfall

The land line route shown in Figure 3-2 was selected to avoid slope failure and to avoid the bed of a small stream adjacent to the Naval Facility. It was also necessary to locate the beach end of the line as far south as possible to prevent interference with existing cables during offshore line installation. The selected route crossed dense vegetation. This vegetation was considered beneficial because it reduced the danger of future erosion. The easement for this route was acquired by WESTNAVFACENGCOM.

Based on the easement survey performed by WESTNAVFACENGCOM, the estimated length of the land line was 850 feet. In order to allow for possible rerouting of the line and to provide for slack, a 1,000-foot length of pipe was procured for the land line.

The major design consideration for the land line was the selection of the wall thickness of the polyethylene pipe. The available pressure head from the sewage treatment plant to the beach was approximately 260 feet or 113 psi. The pipe selected had a long-term pressure rating of 125 psi, which was the nearest available standard wall thickness. It was assumed that the planned intermittent sand filter would be operated at a flow rate of 1,000 gallons in 10 minutes. Flow calculations indicated that the pipeline would have about $2\frac{1}{2}$ times the capacity required for this flow rate.

The length of the offshore line was determined by the placement of the diffuser. At a water depth of 50 feet, the diffuser would not be significantly affected by wave action. It required 3,000 feet of pipeline to reach this depth. Based on previous experience with existing cables, it was determined that the pipeline would be buried by natural surf and wave action provided that the in-water weight of the pipeline was at least 8 pounds per foot. Therefore, the heaviest available pipeline section was selected; its in-water weight was $10\frac{1}{2}$ pounds per foot. This eliminated any requirement for external stabilization.

The diffuser (Figure 3-3) was a 4 by 8-foot concrete pad with a thickness of 18 inches. Steel pipes were cast into the concrete to connect the pipeline and two risers. The risers permitted discharge in the event that the block was buried by the deposition of sand. The risers had inverted U-traps to prevent sand from entering and plugging the line. The low profile of the diffuser block minimized wave forces.

The anchor blocks (Figures 3-4 and 3-5) at the top of the hill and at the beach were designed to stabilize the line and to provide connection points for the land and offshore lines. A short length of the land line immediately outside the Naval Facility's fence was buried to permit the free passage of livestock on the surrounding farmland. A French drain, consisting of 4-inch perforated PVC pipe and gravel, was installed in the bottom of this trench to limit possible erosion.

FIGURE 3-3

Diffuser

(See picture, next page.)

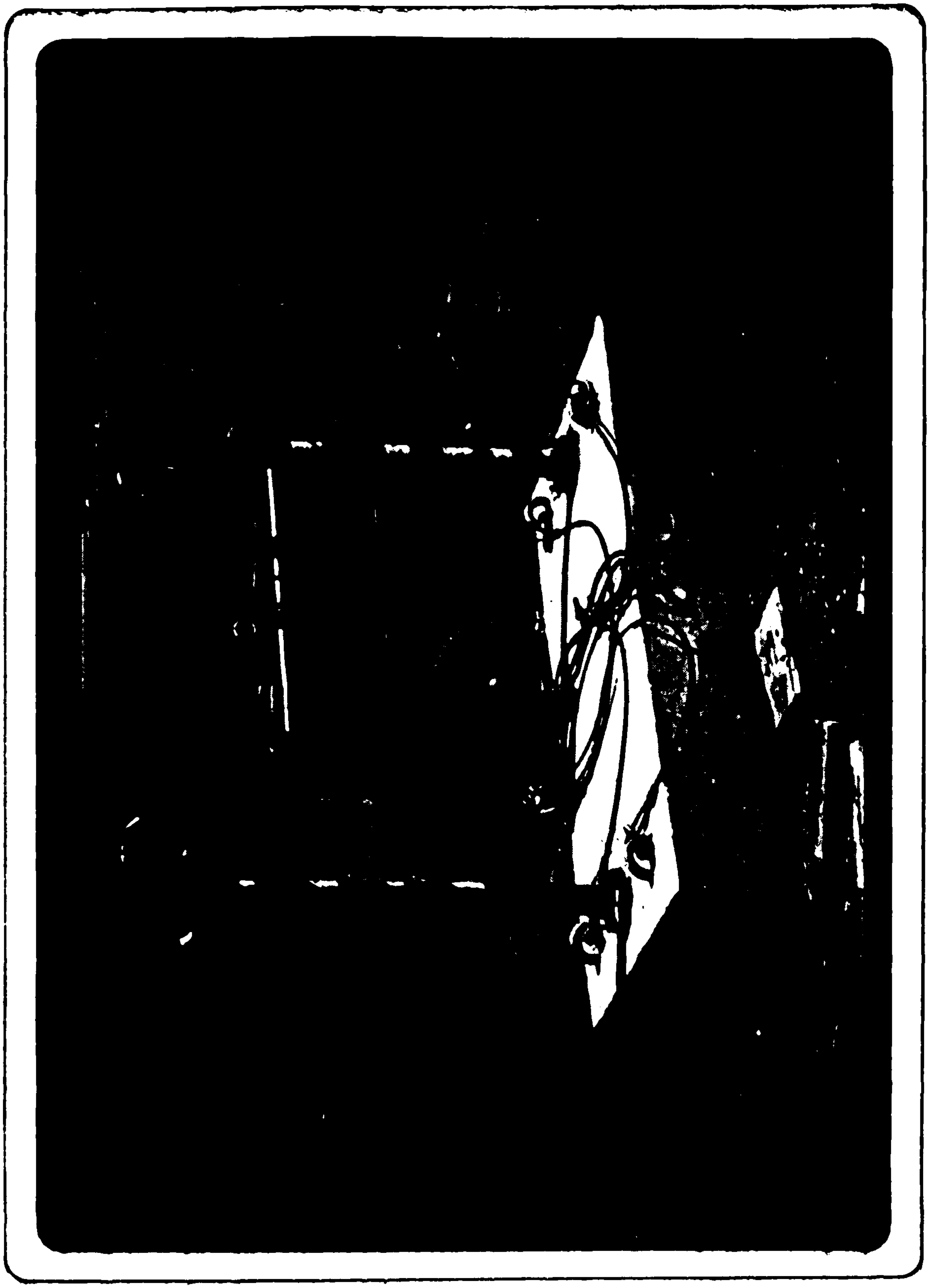


FIGURE 3-4

Hilltop Anchor

(See picture, next page.)

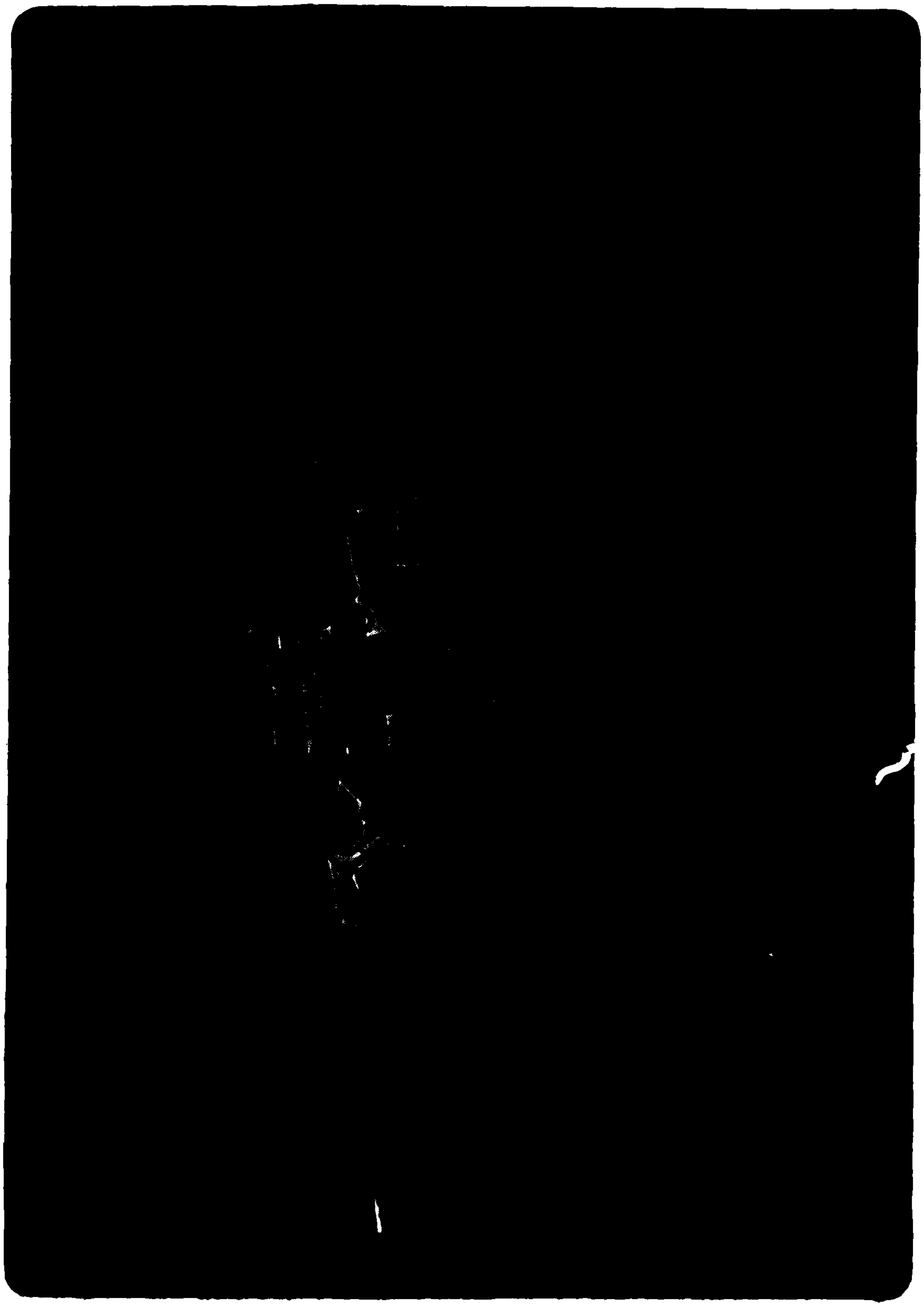
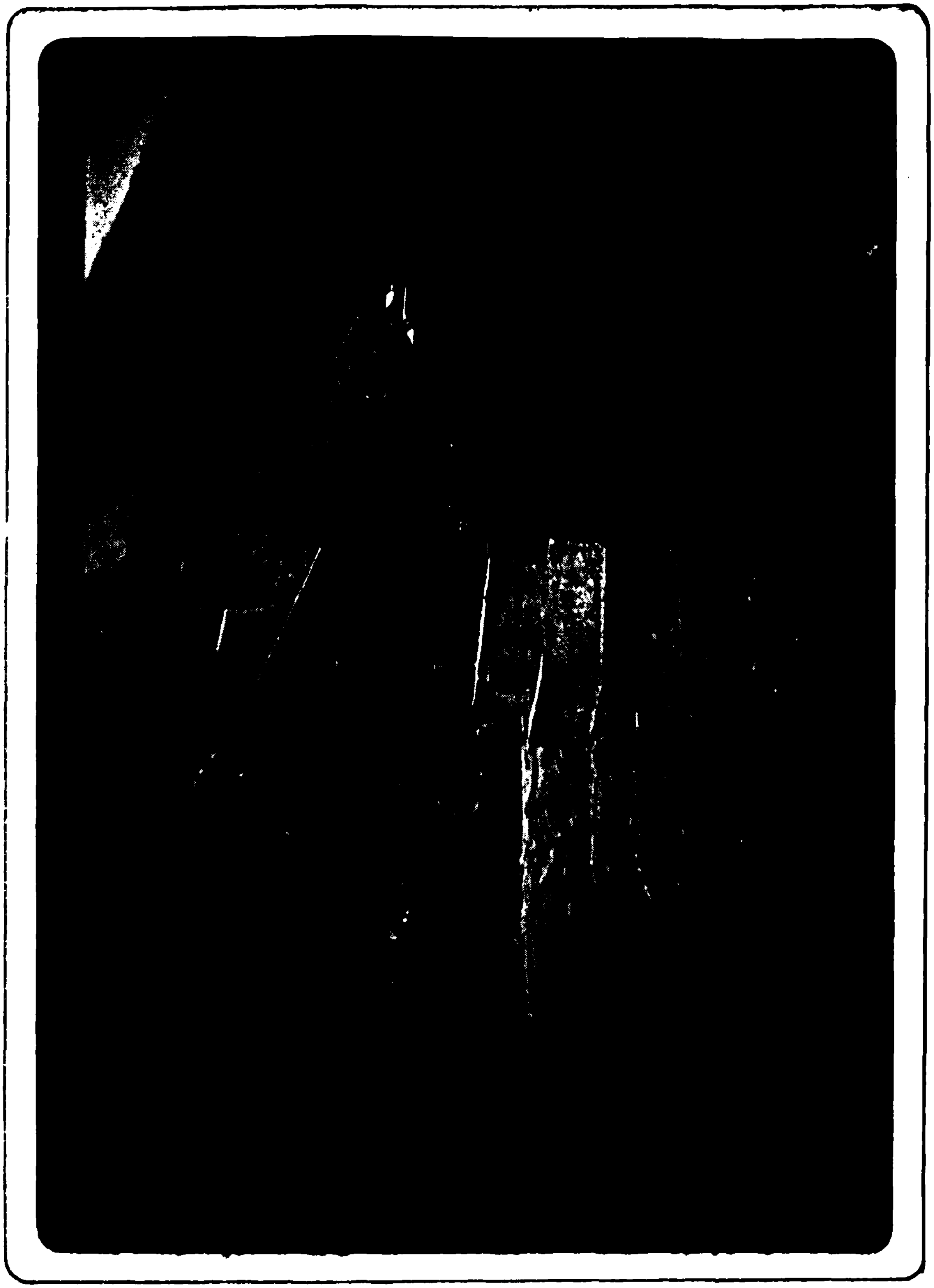


FIGURE 3-5

Beach Anchor

(See picture, next page.)



3.3 INSTALLATION SYSTEM DESIGN. A complete description of the installation system is given in the Project Execution Plan (PEP), which was jointly prepared by CHESNAVFACENGCOM and UCT-2. The factors that led to the selection of this installation system and a brief description of the system are summarized in this section.

3.3.1 Offshore Work Platform. The offshore line installation required a moored work platform which served as a base either for pulling the pipe off the beach seaward or for holding the pipe to be pulled onto the beach. The work platform had to be placed in a 4-point moor to provide stability against incoming waves, winds, and lateral tidal currents, and to provide a reaction to the pipe's pulling forces. A minimum free deck area of approximately 20 by 100 feet was required to provide for storage and working space. A capability to handle a 5-ton weight over the side or bow was also required to overboard the diffuser block. The availability of flattop barges, commercial and Navy-owned, was investigated, but the cost of outfitting and mobilizing the barges, including tug services, was excessive. It was determined that an LCU (1610 class) could be made available by ACB-1. The LCU had been modified by adding an A-frame, which reached over the bow, and a 10-ton winch. It was capable of transit to the site without tug services, could set its own mooring anchors, could handle and overboard the diffuser block, and had adequate deck space for storage and work. The LCU is shown in Figure 3-6.

3.3.2 Installation Methods. In general, the preferred method for offshore line installation would have been to assemble the pipe on the beach and pull it into the water, because better working conditions and more working space can usually be provided on shore. However, at Centerville the width of the beach was restricted, and the soft sand made it difficult to transport large quantities of materials to the site from the nearest access point one-half mile away. Thus, the alternate approach was adopted, that of placing the pipe on the work platform and pulling it onto the beach. Because the selected pipeline material could be handled as a cable, the operation could be accomplished using well-established cable landing procedures.

The installation procedure called for the pipe to be pulled ashore by attaching a hauling line to the pipeline's bitter end and pulling it on the beach with a bulldozer. Because of the narrow beach, the hauling line was reeved on a sheave to make a 90 degree turn, and the bulldozer travelled down the beach parallel to the shoreline. The hauling line was a continuous, 7,000-foot length of 6-inch circumference, double-braided nylon. About 3,200 feet of hauling line was required to reach the beach, and a shackle was inserted into the line (Figure 3-7) to attach the pipe-pulling head. The remainder of the hauling line was tended over the gypsyhead of the winch to provide a back-tension to control the horizontal excursions due to surface currents

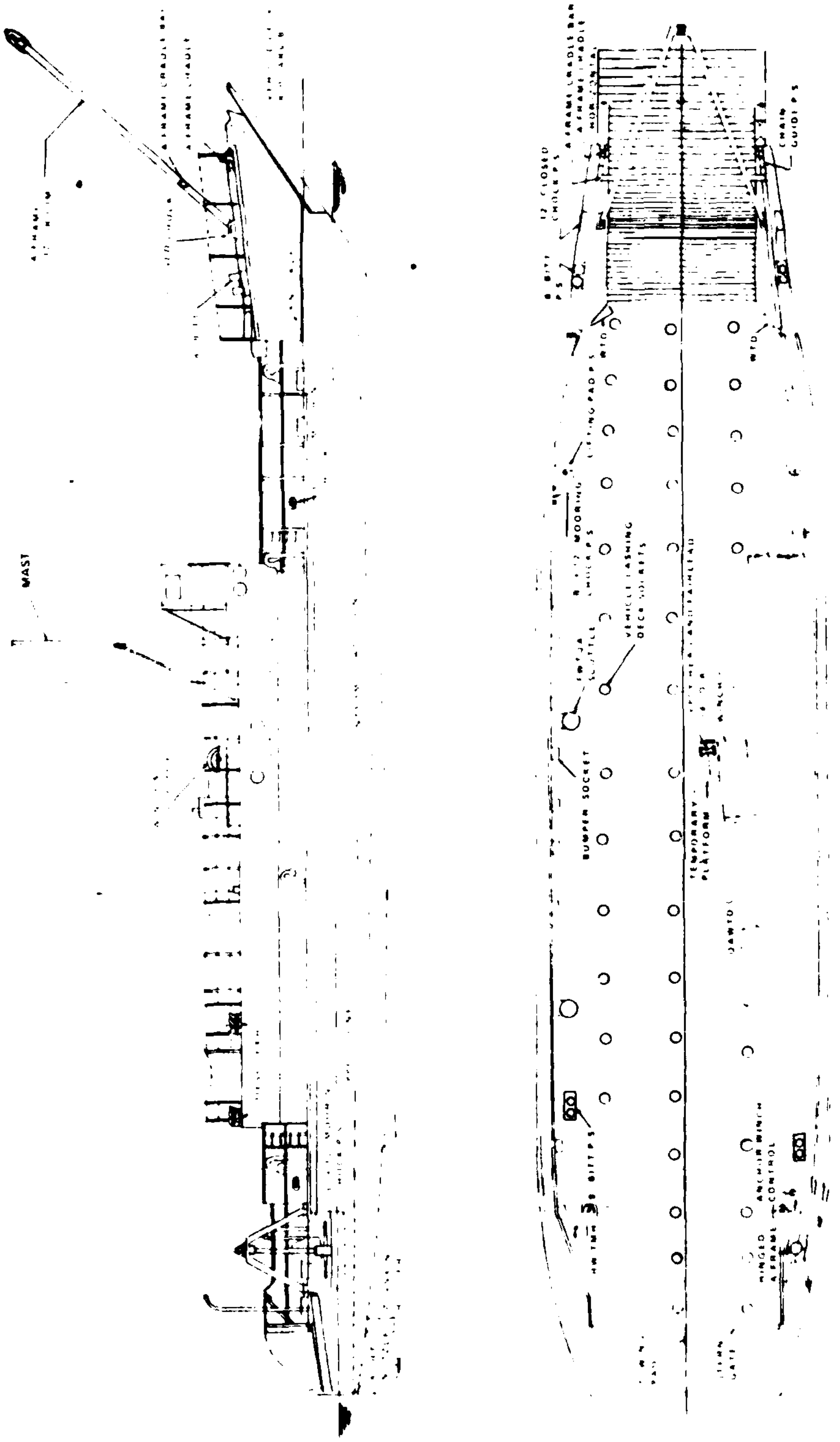


FIGURE 3-6

Landing Craft, Utility (LCU)
Modified With A-Frame

FIGURE 3-7

Shackle Inserted into Hauling Line

(See picture, next page.)

and winds. The pipe was under minimal tension. Float balloons were attached to the pipe for buoyancy. When the pipe was in the water and the shoreward end was pulled to the location of the beach anchor, the float balloons were cut free and the pipe sank in place and was flooded. A back-tension of approximately 20,000 pounds was applied prior to sinking the pipe to straighten the line.

The land line installation was performed by pulling the pipe down the hill to the beach. A 1-5/8-inch polypropylene line was used as the hauling line. The line was attached directly to the pipe-pulling head and no back-tension line was required. The turning points in the land line route required fairleads as indicated in Figure 3-2.

3.4 OTHER INSTALLATION EQUIPMENT. In addition to the LCU, bulldozer, hauling line, float balloons, and beach sheave, the major items of equipment for the installation included:

a. A LARC V for assisting in LCU mooring, pulling the hauling line ashore, personnel transfer between the beach and LCU, and diving operation support.

b. A 5-ton cargo truck and a jeep, both with sand tires, for hauling equipment and personnel.

c. A front-end loader with backhoe, for burying the beach sheave deadman and the anchor blocks.

d. A backup bulldozer, borrowed from the National Guard in Eureka, California, for the offshore line installation in the event the UCT-2 bulldozer broke down during the operations.

A complete equipment and materials list is provided in the PEP.

CHAPTER 4

FABRICATION AND TRANSPORTATION

4.1 PIPELINE FABRICATION. The pipeline was procured from Simplex Wire and Cable Company and was fabricated in their plant at Newington, New Hampshire. The pipe was fabricated as a single, 4,000-foot length. It was then cut into a 1,000-foot length for the onshore line and a 3,000-foot length for the offshore line. Initial installation planning called for the pipe to be delivered in these lengths will bolted flange connections on each length. Two pairs of extra bolted-flange connections were ordered in the event a field splice had to be made. However, the 3,000-foot length was subsequently cut into three, 1,000-foot lengths, and the spare connections were used to terminate these lengths. The pipe was delivered on timber reels, which were designed by Simplex and fabricated by a subcontractor.

4.2 OTHER FABRICATION. The diffuser, risers, and anchor blocks were fabricated by UCT-2 in Port Hueneme. UCT-2 also fabricated the timber cribs, acquired the shafts for the pipe reels, and performed a variety of miscellaneous fabrication tasks including the beach sheave deadman and bridle, turning point fairleads, float balloon harnesses, diffuser lifting bridle, and mooring point markers. ACB-1 assembled the LCU mooring hardware and fabricated the bow guide posts for the LCU ramp.

4.3 TRANSPORTATION. During early discussions with Simplex concerning the manufacture and shipping of the pipe, it was suggested by Simplex that the least expensive means of shipment would be to have a ship load the pipe directly at the Simplex cable-loading dock, and transport the pipe to the West Coast. This suggestion was tentatively adopted for initial planning purposes, and the pipe was ordered F.O.B. at the manufacturer's plant. Inquiries were made with the Military Sealift Command (MSC) and Military Traffic Management Terminal Service (MTMTS), Bayonne, New Jersey, concerning the availability of ship transportation. It was determined that it would not be feasible to route a ship to the Simplex plant to load the pipe, and that the pipe would have to be shipped to Bayonne or Brooklyn for loading on a ship. It was also determined that although sea transportation could meet the delivery schedule, a significant risk did exist that the pipe would be delivered too late to meet the installation weather window. Because of the additional costs and the risk of late delivery, sea transportation was eliminated from consideration.

Shipment by truck or rail were compared and it was found that the costs of truck transportation were excessive. The remaining alternative was rail transportation, and two options existed. The pipe had originally been ordered in two pieces, one of 1,000-foot length and one of 3,000-foot length, assuming availability of ship transportation. It could have been shipped in these lengths by coiling the pipe in flat loops inside gondola cars. Several cars would have been required and the pipe would have been led from car to car with a slack length spanning between cars. Car connections would have been welded together to prevent accidental uncoupling. This option was finally eliminated because of the difficulty of acquiring a sufficient number of extra-wide gondola cars that would permit the coiling of the pipe without exceeding minimum - bend radius requirements.

The second option and the one selected was to cut the 3,000-foot length into three lengths and ship the pipe on timber reels. This option had been discussed in the early meetings with Simplex and was not initially selected because of the expense of fabricating the large single-purpose reels. However, it ultimately became the only feasible means that would permit delivery with a reasonably small risk of delay enroute.

A contract modification was executed to have Simplex cut and reterminate the pipe, design and acquire the reels, and load the reels aboard the rail cars for shipment. The timber reels were 13 feet outside diameter and 9 feet wide, and required special routing.

The pipe was delivered to UCT-2 in Port Hueneme (Figure 4-1) where it was loaded aboard the LCU for transportation to the site. Other equipment and materials necessary for the installation were transported either in the LCU or overland using NCF equipment.

FIGURE 4-1

Pipe Delivered on Reels

(See picture, next page.)

CHAPTER 5

INSTALLATION SUMMARY

5.1 GENERAL. Except for minor changes, discussed in section 6.2, sewer outfall installation followed the procedures established in the PEP. All dates given below occurred in calendar year 1975.

5.2 ADVANCE PARTY PREPARATIONS. An advance party from UCT-2 deployed to the site on 4 August. The site preparations included clearing brush from the land line installation route, reestablishing survey control points, installing fairleads at turning points on the land line route, and setting marker buoys for mooring anchor locations. The advance party conducted a diver search in the vicinity of the mooring anchor locations to insure that the installation of the anchors would not interfere with existing cables. The diver search determined that the existing cables did not cross the mooring location

5.3 BOAT PREPARATION AND LOCAL TRANSPORTATION. The timber cribs were loaded into the LCU and secured in place on 11 August at Port Hueneme. Because the pipe had not been delivered, the LCU returned to Coronado to complete preparations (assembly of mooring gear and welding on of the bow guide posts). The pipe was delivered at Port Hueneme on the morning of 15 August, and was loaded aboard the LCU that afternoon (Figure 5-1) along with the remaining gear. The LCU departed for the site on 15 August, arriving in Eureka on the 18th. The reel of pipe for the land line was offloaded and transported to the Naval Facility on 19 August. The LCU then set the mooring anchors, and returned to Eureka to rig the boat and inflate the float balloons in preparation for installing the offshore line.

5.4 LAND LINE INSTALLATION. The land line was installed on 20 August. All preparations were completed by 1000 and the bulldozer began pulling the pipe at 1010. When the pipe began to move off the reel, the fairlead at the upper turning point pulled out of the ground because the soil was too dry and contained too much organic material to develop adequate holding capacity. The fairlead was rerigged using a tree as a deadman. Pulling began again at 1100. No other difficulties occurred, and by 1415 the end of the pipe was at the beach (Figure 5-2). Another 4 hours were required to pull slack into the line to reduce the number and magnitude of suspensions due to the uneven ground. Operations were secured at 1830.

5.5 OFFSHORE LINE INSTALLATION. Four attempts were made to install the offshore line. The installation scheduled for 21 August was postponed because sea conditions were too rough to permit the LARC to enter the surf.

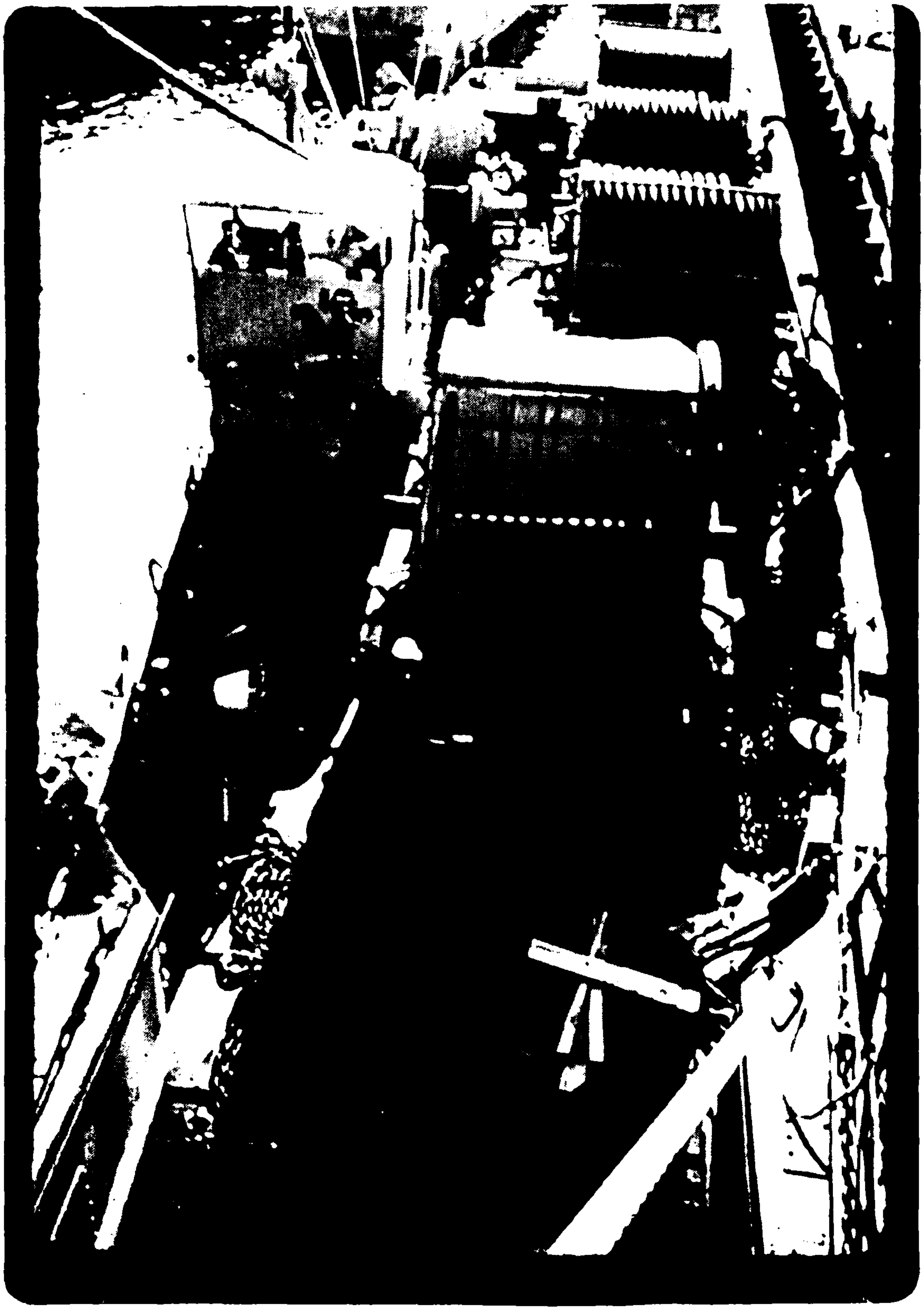
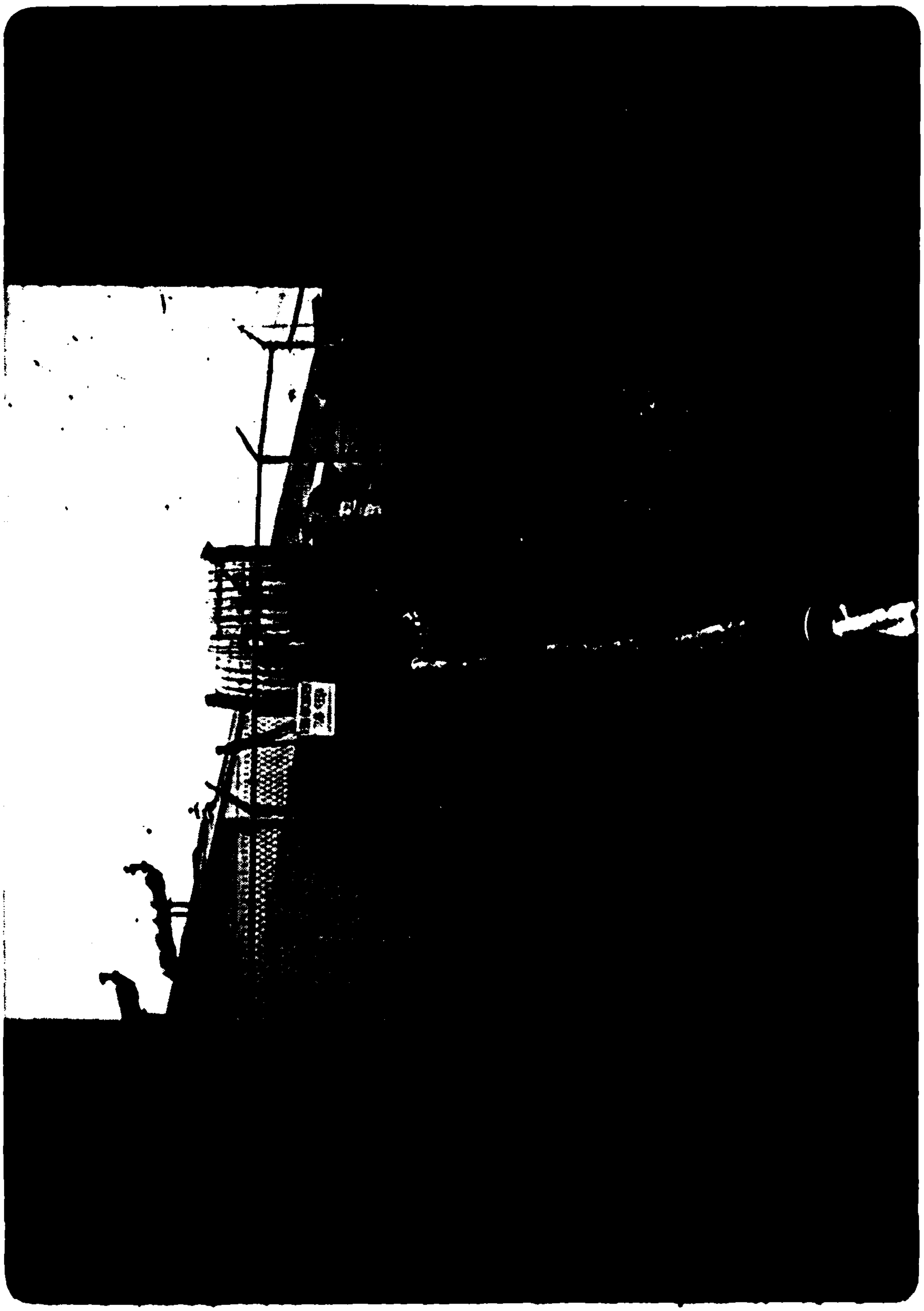


FIGURE 5-2

Land Line Being Pulled Into Place

(See picture, next page.)



Sea operations were then scheduled on a day-to-day stand-by basis, with a "go-no go" decision to be based upon weather and surf conditions.

The first installation attempt was made on 22 August. The LCU was on site by 0800, and the LARC entered the water to assist in entering the moor. Sea conditions were marginal with 6 to 8-foot swells and 2 to 3-foot seas. The LCU spent 2 hours attempting to enter the moor with wind and sea conditions worsening. At 1000 the attempt was abandoned because conditions were too poor and it was too late to complete the mooring and start operations. A 4-day period of bad weather followed, and no attempts were made.

The second attempt was made on 27 August with good weather and sea conditions. The LCU was in the moor and ready to begin operations by 1000. The LARC, while underway to the LCU, lost power and began to drift toward the surf zone. Power could not be regained, and the LCU had to vacate the moor and take the LARC under tow to Eureka. The LARC's mechanical trouble was found to be a faulty fuel pump.

A third attempt was made on 28 August. The plan called for the LCU to straighten out the mooring lines and reset the anchors, because the emergency departure of the previous day had left the moor in disarray. In addition, a replacement fuel pump had to be found for the LARC. However, because of the good sea conditions existing when the LCU arrived at the site, it was decided to attempt the installation without the LARC. The LCU approached within 150 feet of the beach, and the hauling line was landed with the aid of a shotline and messenger (Figure 5-3). The LCU backed off the beach and attempted to enter the moor, with the assistance of a *ZODIAC* rubber boat to handle the mooring lines. Attempts to enter the moor were continued for 2 hours. However, the ZODIAC was ineffective in handling the mooring lines because of wind, rough seas, and inadequate power. During the 2 hours, southerly winds and currents drove the LCU north of the mooring site, and the attempt was abandoned when it became too late to begin operations.

The fourth attempt to install the offshore line was made on 29 August. The weather and sea conditions at the beach at 0600 were observed to be good. Incoming swells were 3 to 5 feet with no seas; the winds were light. The weather forecast predicted clear weather and continued light winds. All personnel and equipment were assembled on the beach by 0900, with the LCU standing by offshore. The LCU entered the moor with LARC assistance, and was ready to start operations by 1000. The LARC towed the hauling line to the beach where it was connected to the bulldozer. The LARC then returned to the LCU to transfer UCT-2 personnel, and all personnel and equipment were ready by 1100. The bulldozer began pulling the pipe ashore at 1115, and the first reel was emptied at 1203 . Figure 5-4 shows the float

FIGURE 5-3

LCU Landing Hauling Line at Beach (Third Attempt to Install Offshore Line)

(See picture, next page.)

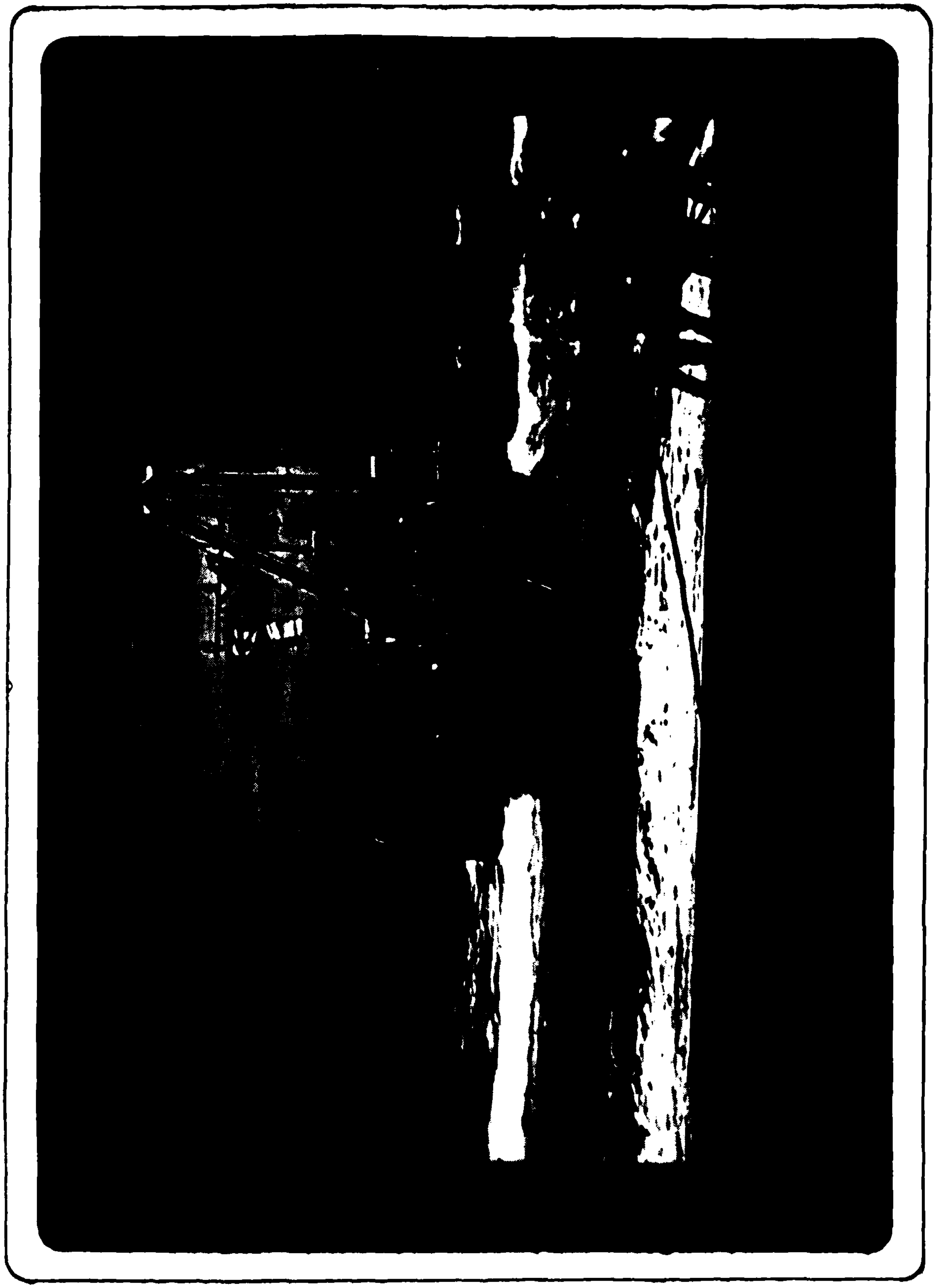
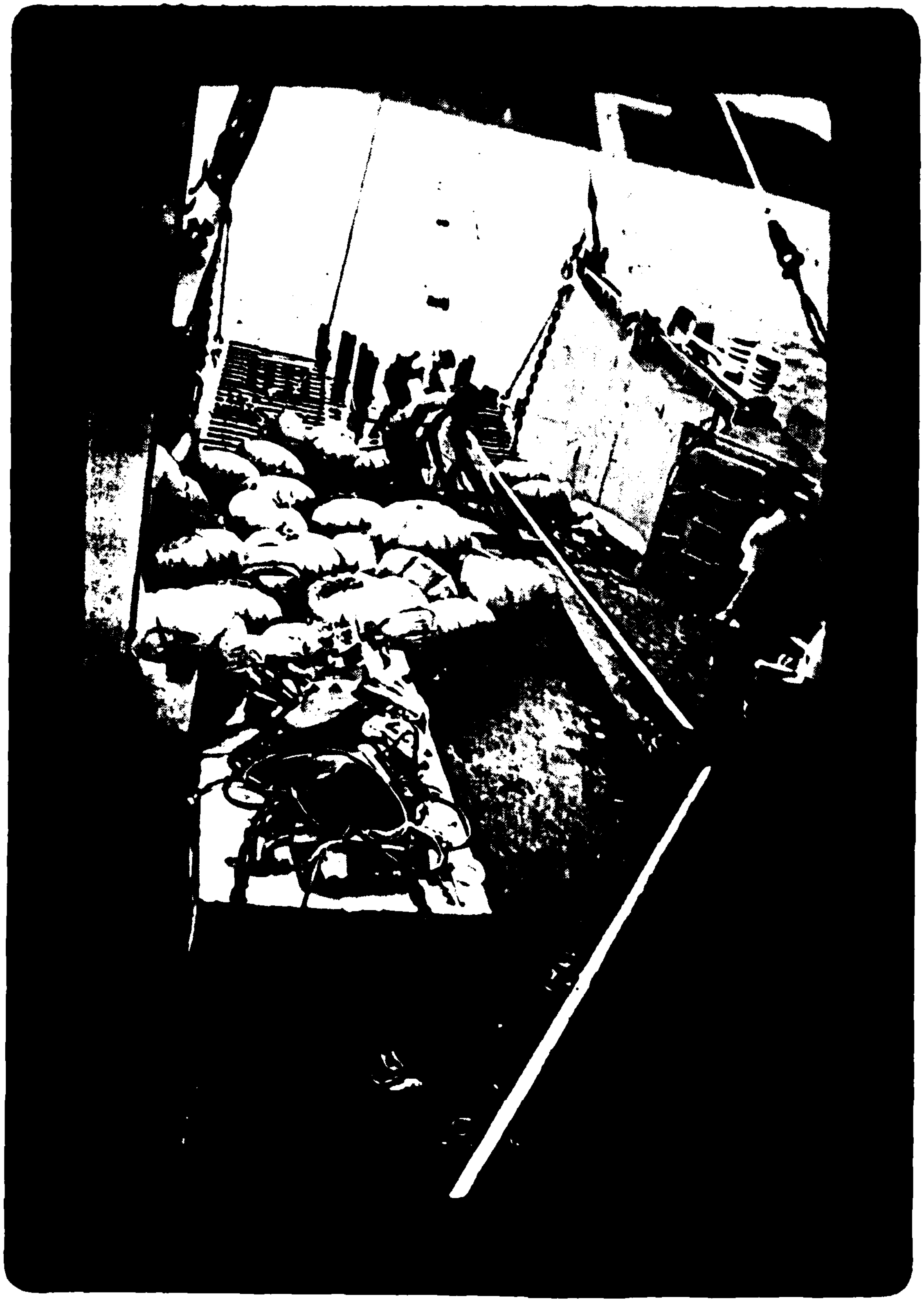


FIGURE 5-4

Float Balloon Tying Operation on LCU

(See picture, next page.)



balloon operations on the LCU. The connection between the first and second sections of pipe was made, and the bulldozer resumed pulling at 1227. The second reel was emptied at 1245. A second connection was made and pulling of the third reel started at 1310. The third reel was emptied at 1330. At this point the shoreward end of the pipe was 30 to 50 feet from the beach and 80 to 100 feet from the beach anchor location. It was estimated that the center of the pipe line was about 100 feet north of the straight line between the bow of the LCU and the beach anchor location (Figure 5-5). The decision was made by the OIC of UCT-2 and the senior CHESNAVFACENGCOM engineer to pull the pipeline the remaining distance to the beach anchor location and sink and flood the pipeline without first attaching the diffuser. The reasons for this decision are discussed in Section 6.2.1.

The flooding valve was attached to the pipe's seaward end, and at 1430 the shore end was pulled to the beach anchor location. Cutting away the float balloons to sink the pipe was begun from the shore end at 1500 and completed by 1700. The diffuser block was overboarded and placed on the bottom within 10 feet of the end of the pipeline.

Two diving operations were conducted to attempt to attach the diffuser block to the pipeline. The first diver team cleared all lines and found that the pipeline/diffuser connection was pointed seaward rather than shoreward. The divers rigged a manual grip hoist between the end of the pipe and the connection to turn the block around and pull the pipe and connection together. At this point the first diver team had to leave the water because of no-decompression time limits. The second diver team attempted to operate the grip hoist to turn the block but were unsuccessful. The grip hoist was rerigged but still would not operate properly. At this point, the second team also reached the limit of dive time and diving operations had to be suspended at 2000 because of darkness.

While the diving operations were in progress, a crew buried the beach anchor and offshore line and made the connection between them. All operations were secured at 2035.

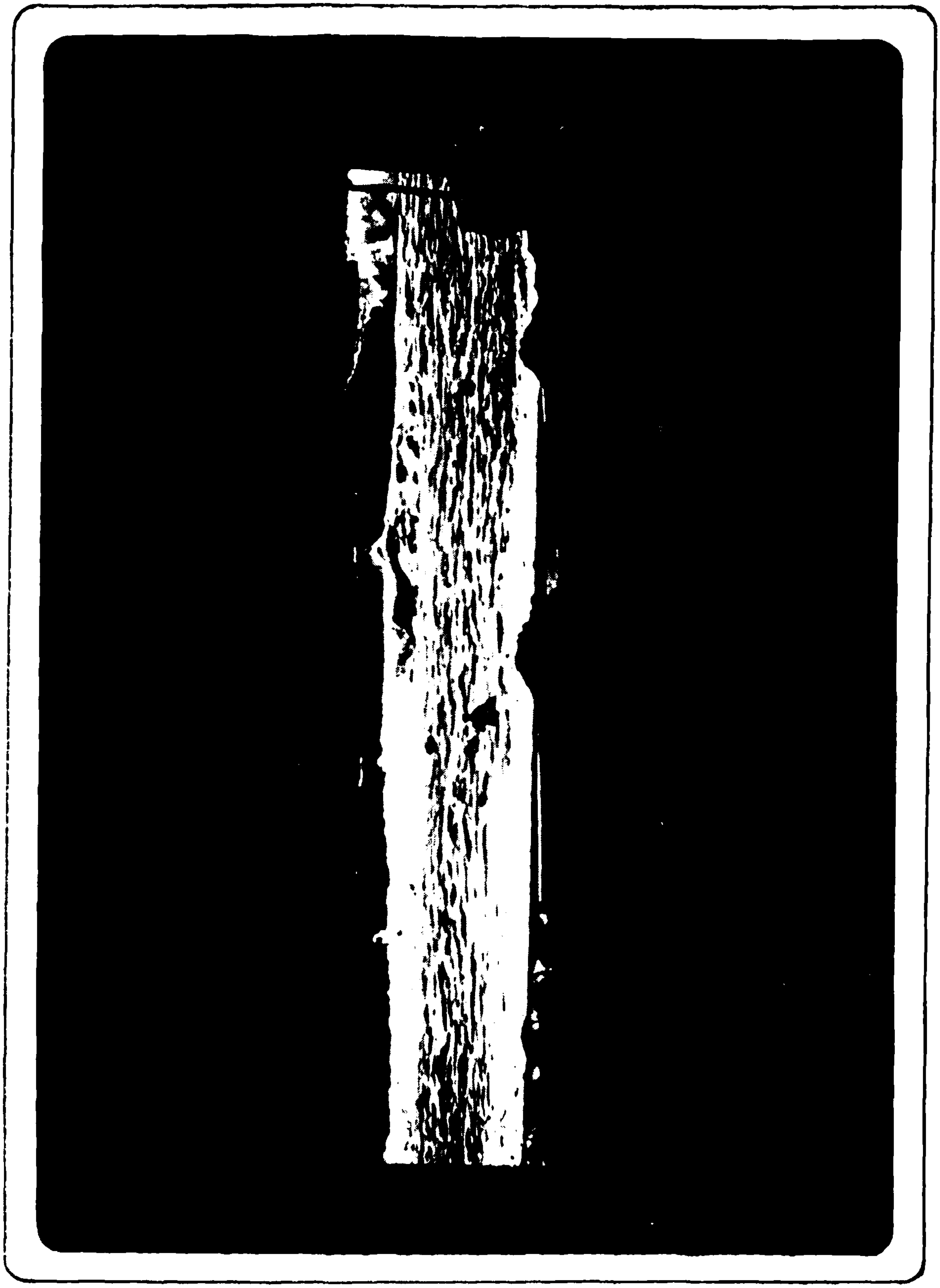
On 30 August the land line was connected to the beach anchor and buried. The beach area was regraded to natural contours. The locations of the beach anchor and marker buoys were surveyed. Because the remaining diving operations could be conducted from the LARC, the LCU returned to Coronado after retrieving the mooring system and loading nonessential equipment.

Because of the heavy work schedule of the previous two days, 31 August and 1 September (Sunday and Labor Day) were observed as liberty days. Winds and rough seas prevented diving operations on the following two days.

FIGURE 5-5

Offshore Line Installation, Location Shown by Float Balloons

(See picture, next page.)



Diving operations were resumed on 4, 5, and 6 September to complete the hookup of the diffuser to the pipeline. Two dives were made on 4 September. The first dive team relocated the end of the pipeline and the diffuser block, and inspected the pipeline shoreward for a distance of about 400 feet. At least half of the pipeline was buried, and in some places the pipe was completely submerged. The first team cleared away lines that had been tied between the end of the pipe and the diffuser block, and rigged the manual grip hoist to turn the block so the connection would point shoreward. The second team checked the grip hoist rigging and attached an inflatable lift bag to the diffuser block to reduce friction on the seafloor when the block was moved. However, the lift bag harness broke while the bag was being inflated. Diving operations were suspended because the replacement lift bag had been loaded aboard the LCU by mistake, and attempts to repair the lift bag harness were unsuccessful. A replacement lift bag was ordered from Port Hueneme.

On 5 September, two dives were attempted. On the first dive, the divers attempted to use the broken lift bag with a harness of nylon line, but they could not safely control the bag. The team then rigged a wire rope between the end of the pipeline and the pipeline/diffuser connection, and tied a 1½-inch synthetic line to one of the lifting eyes of the diffuser block. The synthetic line was attached to a towing post on the LARC, which pulled seaward to rotate the block and align the connection with the end of the pipeline. When this was accomplished, the pipeline termination and diffuser connection were approximately 10 feet apart and in alignment. The second team of divers entered the water to rig the grip hoist and begin pulling the diffuser to the pipeline. However, a diver regulator malfunction caused the dive to be aborted, and diving operations were suspended because of increasing winds and seas. The replacement lift bag was delivered that afternoon.

On 6 September, three dives were conducted. The first team rigged and inflated the new lift bag, rigged the grip hoist, and started pulling the block to the pipeline. The second team pulled the diffuser block to the pipe's termination point and prepared the first bolt of the connection. The third team completed the connection, attached the risers to the diffuser, and cleared away the lift bag and auxiliary flotation buoys. All operations were secured, and the offshore line was completed at 1930.

5.6 MISCELLANEOUS OPERATIONS.

5.6.1 <u>Land Line Completion</u>. During the bad weather period of 23-26 August, when sea operations could not be conducted, several operations were performed to complete the installation of the land line. These operations included: cleaning up the land line route; installing sand bags and

reseeding the grass to reduce erosion; removing the fairleads from the turning points on the slope; installing the hilltop anchor; excavating a trench for the livestock crossing; installing a French drain in the trench; burying the land line in the trench; and cutting and reterminating the pipe to fit the location of the hilltop anchor.

5.6.2 Sewage Treatment Plant Hookup. At the request of the Naval Facility Public Works Officer and the WESTNAVFACENGCOM Engineer in Charge, a test hookup between the sewage treatment plant and the outfall line was designed and installed. The existing discharge was detached from the treatment plant and connected to the outfall line with 4-inch polyvinylchloride pipe and fittings. The discharge was then blocked with a blind flange. This hookup was used during system checkout, and was left in place on a trial basis. The Naval Facility, WESTNAVFACENGCOM, EPA, and the State of California will determine whether the test hookup can remain without installing sand filters, as originally planned.

5.7 SYSTEM CHECKOUT. Testing of the outfall line was conducted on 7 and 8 September. This test consisted of filling the holding tank of the sewage treatment plant with a firehose and pumping the water to the outfall line through the test hookup. Initial tests on 7 September disclosed a leak in the termination of the land line at the hilltop anchor. The leak was repaired and the line reterminated. Tests resumed on 8 September. During these tests fluorescein sea marker dye was flushed through the line to confirm that the line was operable. After an hour of pumping, the dye marker appeared at the ocean surface above the diffuser location. The dye marker was observed for 1 hour, at which time it had almost completely dispersed parallel to the beach. By 9 September all remaining project personnel with their equipment had returned to their commands.

CHAPTER 6

PROJECT SUMMARY, EXECUTION ANALYSIS, AND LESSONS LEARNED

6.1 PROJECT SUMMARY. The Centerville Beach sewer outfall project was successful as a result of excellent teamwork between the organizations which were involved in planning and executing the project. This teamwork was strengthened by negotiated preplanning agreements and by the willingness of all parties to assume full responsibility for agreed-upon assignments. Variations from the PEP did occur, however, due to field conditions. Those variations that may have had a significant beneficial or adverse effect upon project completion are discussed below along with significant lessons learned. The following are significant accomplishments:

a. The project was completed on time and within budget, despite the occurrence of several days of weather that precluded sea operations and threatened to prevent timely completion.

b. The outfall was tested and found to be fully operational.

c. The outfall was installed as a complete facility with the addition of the connection to the existing sewage treatment plant. It is likely that the facility will satisfy EPA and State of California environmental requirements without additional treatment facilities.

d. The project was completed with no serious mishaps or injury. Even though the operations were designed to be as safe as possible, an element of danger always exists. During the land line installation, the man assigned to watch for signs of failure dove for cover when the fairlead, without warning, pulled out of the ground. The man's hand was scraped, but he returned to the operation as soon as his wound was dressed. The other mishap occurred during the offshore line installation when an LCU crewmember fell overboard. The man had climbed onto one of the timber cribs to free wedges that had been inserted to secure the reel during transit. An unexpected roll caught him off-balance and pitched him over the side. He climbed back onboard unhurt. In general, all personnel were safety-consious.

e. A total of 3,000 feet of pipeline were installed in a working time of 17 hours. This included $2\frac{1}{2}$ hours to moor the LCU, and land and connect the hauling line; 3 hours to pull the pipe off the reels and make the connections between sections; 2 hours to cut the float balloons and retrieve the hauling line; $7\frac{1}{2}$ hours of diving time to connect the diffuser to the pipeline; and 2 hours of miscellaneous activities.

6.2 PEP VARIATIONS

6.2.1 Diffuser Installation. The decision to install the offshore line before the diffuser block was attached added several days to the operation. The factors involved in making this decision were:

a. The procedure that was followed (i.e., sinking the pipe and connecting the diffuser underwater) was included in the PEP as an equal alternative to that of connecting the diffuser aboard the LCU.

b. A complete rehearsal had not been conducted of the procedures for overboarding the diffuser while it was attached to the pipe and the subsequent handling operations required to control the diffuser while afloat. Although all individual components had been handled successfully, the whole operation had not been exercised. Of particular concern was the fact that both longitudinal (shoreward) forces and lateral forces, caused by current drag, had to be resisted, and it was believed that adequate preparations had not been made to control the operation.

c. Several float balloons on the pipe nearest the shore were coming free due to surf action. Although there was no immediate danger of the pipeline sinking prematurely, it was felt that the delay required to attach and overboard the diffuser might permit too many balloons to come free. In addition, observers on the LCU reported that the seaward end of the pipe appeared to be sinking. (The reasons for the pipe's sinking are not known, but possible reasons are discussed in Section 6.2.2).

d. The OIC and CHESNAVFACENGCOM engineer were located at the beach control position where they had observed a progressive increase in surf action (Figure 6-1) during the time between the mooring of the LCU and the arrival of the end of the pipe near the beach. Surf had risen from 3 to 4 feet to 5 to 6 feet, and the impression was that sea conditions were deteriorating. This was in contrast to the personnel on the LCU who observed no apparent change in a smooth, 3 to 4-foot swell condition.

In summary, the decision was made to select the more conservative option for the offshore line installation even though more diving would be required. Subsequent attempts to connect the diffuser on the same day were not successful as explained in Section 5.5. Considering the possible risks as they were perceived at the time, the additional costs of a few days more per diem for project personnel seemed well justified.

FIGURE 6-1

Surf at Beach During Offshore Line Installation

(See picture, next page.)

6.2.2 Float Balloon Spacing. The PEP called for the float balloons to be attached to the pipe every 20 feet, and this plan was initially followed. After about 300 feet of pipe were in the water, the UCT-2 personnel aboard the LCU requested permission to increase the spacing to 40 feet to expedite the laying of the pipe. They reported that the balloons installed thus far were riding well and the absence of rough seas meant minimum dynamic forces on the pendant lines. It was decided that the 20-foot spacing should be maintained for the first 500 feet which would come within the surf zone, after which the spacing could be increased to 40 feet. This left a nominal 100 pounds of excess buoyancy per balloon. The change worked well since it increased the speed at which the pipe could be unreeled, thus decreasing the overall operations time. However, the increased spacing may have been partly responsible for the apparent sinking of the seaward end of the pipe. As the pipe was unreeled, it was discovered that water from the factory's hydrostatic tests apparently remained in the pipe. This increased the net unit weight and probably caused the sinking. On balance, the changed spacing was probably beneficial, but such a decision can only be made in the field. In the future, it would be prudent to try to maintain a greater reserve buoyancy per balloon.

6.2.3 LCU Mooring. The PEP called for the LCU to enter the moor the day before the offshore line installation and to remain moored overnight to permit operations to begin at first light. However, the changeableness of the weather and sea conditions at the site made this plan inadvisable. Attempting to predict the next day's wind, swell, surf, and fog conditions based on observations in the early afternoon was too risky. Because the LCU could transit from Eureka in less then 2 hours and enter the moor in less than 1, providing the weather was in good condition, it was determined that a "go-no go" decision made no later than 0700 would permit the operation to be completed in that day. This procedure may also have affected, indirectly, the final decision to install the pipeline without attaching the diffuser aboard the LCU, since about 3 to 4 hours of good weather and available daylight were lost in LCU transit and mooring. These hours might also have permitted the underwater diffuser connection to be made on 29 August since diving operations had to be suspended because of darkness.

6.2.4 Proof Tests of Pipe Hauling System. The fact that the hauling line was not landed until immediately before the pulling operation was to start meant that the proof load test of the system, and particularly the beach sheave deadman, could not be conducted as planned. In anticipation of this, the deadman was tested in advance by attaching the bulldozer directly to the bridle and pulling on the deadman. Load was measured with an in-line dynamometer; a maximum pull of 18,000 pounds was exerted with no obvious

movement of the attachment point. It was decided that pulling forces would be held to no more than 12,000 pounds, except during backhauling to reduce horizontal excursion of the pipeline, and that a backup deadman would be employed. The backup deadman was formed by burying the bucket of the front-end loader in the sand and attaching lines between the bucket and the beach sheave. This system had been used as the deadman for the sheave during land line installation and had been successfully subjected to loads on the order of 20,000 pounds.

6.3 LESSONS LEARNED

6.3.1 Transportation. The most significant lesson of the project is that the transportation of large items of equipment or materials is a complex and expensive procedure. Ideally, a simple rule-of-thumb would be: "Never buy anything that cannot be shipped in a standard railroad boxcar or on a standard flatcar." An even better rule would be: "Keep the size and weight compatible with highway size and load limits." If a procurement necessarily involves oversized items, transportation planning and arrangements must begin during the design phase of the project, well before fabrication is started. In the Centerville Beach project, transportation requirements significantly affected installation procedures since the pipe was eventually delivered on reels. This materially aided the project because installation from reels was simpler and safer than the planned approach of coiling the pipe in flat loops. On the other hand, a large amount of planning and design effort expended on the original approach was rendered unproductive.

A feature of the Centerville Beach project that obviously compounded the transportation problem was the distance between the source of the pipe (New Hampshire) and the project site (California). For oversized loads, such as the pipe reels, no simple transportation alternatives exist. Ship transportation would probably have been the cheapest, but required more lead time for delivery than was available. It would also have involved problems in delivering the pipe from the manufacturer to a suitable port, and in loading and securing the reels aboard ship. Highway transportation was considered and was technically feasible, but was costly and slow because of various state requirements concerning permissible travel hours with oversized loads. Such loads also create large logistics problems in securing all required permits in advance.

Transportation by rail, as eventually selected, was found to be satisfactory, but did require special selection of routing and railcars to assure adequate clearances. Finally, once a shipment is committed to either rail or ship transportation, one must face the problem that any real control of a delivery is lost. Rerouting of railcars and of ships does occur and can completely

disrupt advanced planning. For this project, daily calls were made to MTMTS, Brooklyn, to determine the location of the pipe enroute. While tracking the railcars was for the most part effective, periods of 48 hours sometimes elapsed in which no location report was available. One erroneous report stated that the shipment had been rerouted to San Diego.

In summer, although it was recognized early in the project that transportation of the pipe from the East to the West Coast would present major problems, formal investigation of alternatives and planning for transportation was not initiated early enough to assure timely delivery. Had the alternatives been more fully investigated either prior to or immediately after the pipe was ordered, the actual delivery of the pipe might have been advanced by 2 to 4 weeks, and some engineering design and installation planning effort would have been saved.

6.5.2 Planning and Training. The project demonstrated the value of complete planning of all alternative operations. In addition, it emphasized the desirability of rehearsing alternative operations prior to execution, when such rehearsals are feasible.

With respect to planning, PEP provided an excellent background for project execution. The PEP was developed jointly by CHESNAVFACENGCOM and UCT-2. This interface during PEP development between the design and planning organization and the operation forces was invaluable as both parties made significant contributions to the overall plan. It is recommended that the operation forces always have direct participation in preparing the PEP. The scope and level of detail of the PEP originally impressed some as excessive. However, the discipline involved in conceiving, writing, and reviewing the plan was necessary and amply rewarded. Because all responsible personnel were so familiar with the required actions, the project execution was virtually automatic. It is likely that once written and reviewed in final form, the PEP was never referred to in the field.

With respect to training and rehearsal of operations, it is possible that a complete rehearsal of the overboarding of the diffuser while it was attached to the pipe might have changed the decision to install the pipe and diffuser separately. However, it should be pointed out that such a rehearsal would have to have been simulated because it was not feasible to unreel a length of pipe to conduct a rehearsal. A simulated rehearsal might have been unconvincing, considering the complex dynamic loads to which the system was subjected. However, it is recommended that full dress rehearsal be conducted whenever possible.

6.3.3 Float Balloon Pendants. The pendants for attaching the float balloons to the pipe were made of 5/16-inch manila line (9-thread), because a large supply of new line was available. The rated breaking strength of new manila 9-thread is 1,200 pounds which gives a safety factor of about 4 on the nominal buoyancy of a fully-inflated float balloon. As noted previously, a few balloons were soon lost within the surf zone. The loss, due to chafing as a result of surf action, would have been reduced, if not eliminated, by using ½-inch manila line (21-thread), which has a nominal safety factor of about 8.8. The primary advantage is the greater amount of material to resist chafing.

Another cause of loss of some balloons was the breaking of brass halyard snaps that had been spliced into the end of the balloon pendants to speed up the attachment of balloons to the pipe. The balloons were attached by wrapping the pendant line twice around the pipe and clipping the halyard snap onto the pendant between the balloon and the pipe. On some of the recovered balloons the pendant was intact but the snap had broken.

The use of 9-thread had a positive aspect in addition to its lower cost. Because of the 5 to 6-foot surf that was occurring at the time the balloons were to be cut free to sink the pipe, the swimmers found it extremely difficult to follow the pipe to cut the pendants. It was finally decided to transfer the swimmers outside the surf zone with the LARC, and have them cut balloons seaward, allowing the balloons within the surf zone to break free by surf action. While this expedient worked well, it must be balanced against the risk of losing balloons too soon.

In summary, it is recommended that 21-thread be used for float balloon pendants where a surf zone crossing must be made, and that the use of halyard snaps be avoided when loss of float balloons might be critical.

6.3.4 Diver Operations in Surf Zone. As noted above, UCT-2 personnel found it difficult to traverse the surf zone as free swimmers. At the time, a 5 to 6-foot surf was breaking about 500 feet off the beach and up to four smaller breaking waves might appear between the beach and the outermost surf line. The last breaking wave occurred in water about waist deep and had enough force to knock a swimmer down and toss him around. Although the swimmers could have forced their way through the surf zone to cut the balloons free as planned, the procedure described above was adopted in the interest of safety. In similar conditions, diving operations would have been impossible within the surf zone. Even disregarding safety considerations, no useful work could be performed.

6.3.5 Fairlead Design. The fairleads for the pipe at the turning points on the slope proved to be of poor design. A more useful configuration for temporary fairleads is similar to a sheave or snatch block. The fairlead that pulled out of the ground during land line installation was eventually used in this manner (Figure 6-2). In addition, anchoring of the fairleads was not properly considered. The dry soil conditions were not expected because no soil samples were taken in the vicinity of the fairleads. Had the conditions been recognized in advance, a more suitable fairlead/deadman system could have been designed. Also, the usefulness of well-anchored natural objects, such as trees and large boulders, as deadmen for fairleads was initially overlooked. Such objects should be a first choice provided their location is suitable.

FIGURE 6-2

Upper Hill Fairlead Rigged as a Sheave

(See picture, next page.)

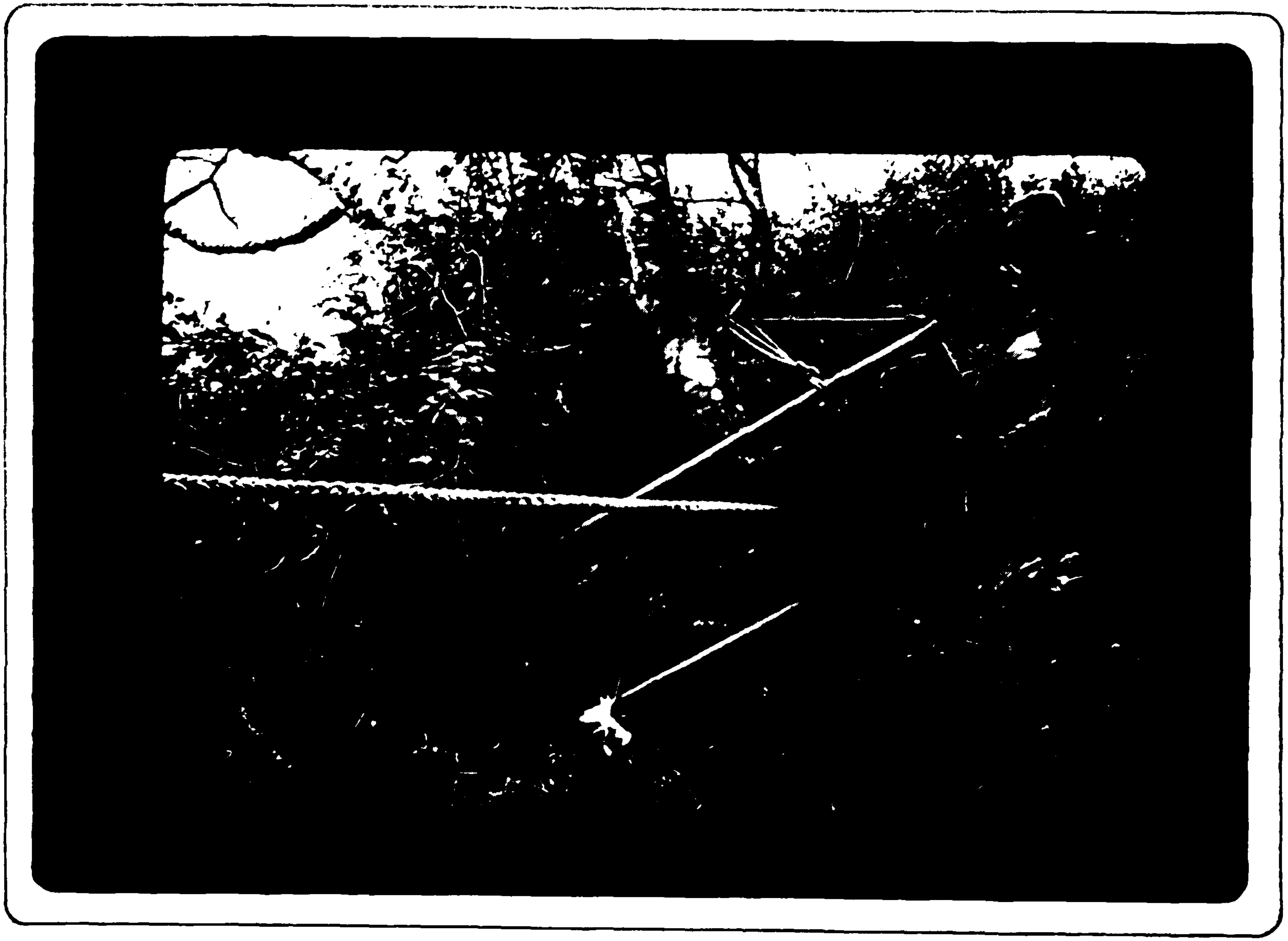


FIG 6-2

END

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